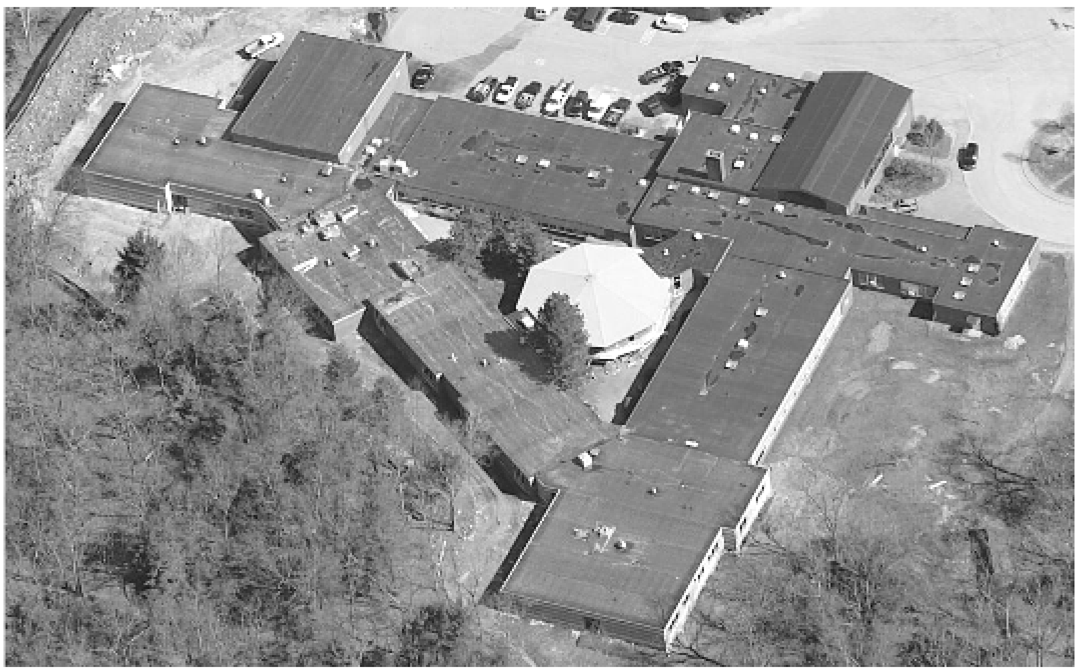
INDOOR AIR QUALITY ASSESSMENT

Huckleberry Hill Elementary School
5 Knoll Road
Lynnfield, MA 01940



Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program

August 2006

Background/Introduction

At the request of a parent and the Lynnfield Public School Department, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at each of Lynnfield's public schools. These assessments were jointly coordinated through Patti Fabbri, Parent/IAQ Representative, Thom Forbes, Facilities Manager, Lynnfield Department of Public Works and Jim Nugent, Director, Lynnfield Health Department.

On May 10, 2006, a visit to conduct an assessment at the Huckleberry Hill Elementary School (HHES) was made by Sharon Lee, an Environmental Analyst in the CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Ms. Lee was accompanied during the assessment by Ms. Fabbri and Mr. Forbes.

The school is a one-story red brick building constructed in 1960 and underwent renovations in 2004. The school consists of general classrooms, kitchen, cafeteria, library, gymnasium locker rooms, music rooms, art rooms, computer rooms, an all purpose room and office space.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Hnu, Model 102 Snap-on Photo Ionization Detector (PID). Moisture content of water-damaged materials was measured with a Delmhorst, BD-2000 Model, Moisture Detector equipped with a Delmhorst Standard Probe. CEH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 400 kindergarten through fourth grade students and approximately 60 staff members. Tests were taken under normal operating conditions; however several classrooms were unoccupied due to end of the year activities. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in 38 of 41 areas surveyed, indicating poor air exchange in the majority of areas surveyed. Fresh air in classrooms is supplied by computerized unit ventilator (univent) systems (Pictures 1 and 2). A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building and returns air through an air intake located at the base of the unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Adjustable louvers control the ratio of outside to recirculated air (Figure 1). Univents were operating in all but one area (room 332), during the assessment. This univent had reportedly been turned off due to excessive noise. Obstructions to airflow, such as items stored on or in front of univents were seen in a number of areas (Picture 1). In order for univents to provide fresh air as designed, units must be activated while rooms are occupied and air diffusers should remain free of obstructions.

In addition to mechanical ventilation, most rooms at the HHES also have ceiling fans (Picture 4). These ceiling fans help to circulate air within the room, especially during warmer months when windows are open. Ceiling fans were not operating at the time of assessment.

Exhaust ventilation for classrooms is provided by different means in each of the wings. Mechanical exhaust ventilation for classrooms in the 100-series wing and some classrooms in the 300-series wing is provided by rooftop mechanical exhaust fans ducted to ceiling or wall-mounted exhaust vents (Pictures 3 and 4). The majority of exhaust vents were operating; however several appeared to be operating weakly during the assessment (Table 1). The location of some exhaust vents can also limit exhaust efficiency. In several rooms, exhaust vents are located near hallway doors (Picture 3). With hallway doors open, exhaust vents in these rooms will tend to draw air from both the hallway and the classroom reducing the effectiveness of the exhaust vent to remove common environmental pollutants.

Mechanical exhaust ventilation for classrooms in the 200-series wing is provided by unit exhaust ventilators (Picture 5). A unit exhaust ventilator appears similar to a univent, but removes air from the classroom and exhausts it out of the building. Unit exhaust ventilators appeared to be off or operating weakly in several areas during the assessment. Exhaust vents/ventilators were also obstructed by various items in a number of areas, restricting airflow (Picture 5). As with univents, unit exhausts should be allowed to operate as designed and free of obstructions. Without sufficient supply and exhaust ventilation, normally occurring environmental pollutants can build-up and lead to indoor air quality/comfort complaints.

Mechanical ventilation for interior rooms and common areas (e.g., offices, media center) is provided by rooftop air handling units (AHUs). Fresh air is distributed via ductwork connected to ceiling-mounted air diffusers. Return vents draw air back to the AHUs through wall or ceiling-mounted grilles. These systems were operating during the assessment. Local airflow to each air diffuser is controlled by a variable air volume (VAV) box. Each VAV box has a set of thermostat-controlled dampers that open or close depending on the temperature demand for a serviced area. Once the thermostat detects that the temperature has reached a predetermined level, the VAV box dampers close until heating or cooling is needed. VAV boxes also control the provision of fresh air to a serviced space. During times that the temperature of a space is adequate, the VAV box closes its damper and limits the amount of fresh air. In contrast, if the thermostat calls for the HVAC system to provide heat, the AHU fresh air intake damper would close to increase the temperature of the air in the ductwork and occupied spaces. Airflow would be noted from the ceiling air diffusers because the VAV box dampers are open, but fresh air supply would be limited by the closing of the rooftop fresh air intake damper.

While it has the advantage of energy conservation and lower operating costs, VAV box systems may cause problems of insufficient outside air supply. For example, once the temperature requirement is met, airflow drops. Airflow can drop to zero in poorly performing HVAC systems (Plog, Niland and Quinlan, 1996).

An AHU regulated by a carbon dioxide monitor provides mechanical ventilation to the school's gymnasium. Once a pre-set carbon dioxide reading is exceeded, the AHU and auxiliary fresh air vent (Picture 6) is activated to introduce fresh air. When a second, *lower* pre-set reading is measured by the sensor, the ventilation system is deactivated. Therefore, no mechanical ventilation is provided until the sensor re-activates the system. According to physical education instructors and Mr. Forbes, temperature control issues are often a problem in the gym, since the auxiliary fresh air vent is often open. To improve occupant comfort, Mr. Forbes or the school custodian must manually override the computerized system. The gymnasium's AHU appeared to be operating at the time of assessment; the auxiliary fresh air vent was not open because of manual override. School officials could not identify the date of last calibration for the carbon dioxide monitor/HVAC controller.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment, but should have occurred at some point after construction in 2004.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

Temperature measurements ranged from 68° F to 75° F, which were within or close to the lower end of the MDPH recommended comfort guidelines. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity ranged from 35 to 51 percent, which was below or close to the lower end of the MDPH recommended comfort range in all areas surveyed during the assessment. The MDPH recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. During the heating season, relative humidity levels would be expected to drop below the recommended comfort range. The sensation of dryness and irritation is common in a low relative humidity environment. For buildings in New England, periods of low relative humidity during the winter are often unavoidable.

Microbial/Moisture Concerns

Several areas had water-stained ceiling tiles (Picture 7), which can indicate leaks from the roof or plumbing system. Water-damaged ceiling tiles can serve as a medium for mold and should be replaced after a water leak is discovered and repaired. The American Conference of Governmental Industrial Hygienists (ACGIH) and the US Environmental Protection Agency (US EPA) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). If porous materials are not dried within this time frame, mold growth may occur. Cleaning cannot adequately remove mold growth from water-damaged porous materials. The application of a mildewcide to moldy porous materials (e.g., ceiling tiles) is not recommended.

Musty odors were reported by occupants in several classrooms along the perimeter of the building. The origin of the odor appeared to be from fresh mulch which had recently been spread prior to the CEH assessment. The area where the mulch is located is in close proximity to univent fresh air intakes, which can draw in odors and distribute them throughout the classroom.

Plants were noted in several classrooms and in close proximity to univent air intakes outside the building. In some areas, plants were observed on univents (Picture 8). Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from ventilation sources (e.g., air intakes, univent diffusers) to prevent the entrainment and/or aerosolization of dirt, pollen or mold.

Spaces between the sink countertop and backsplash were noted in several classrooms (Picture 9/Table 1). Improper drainage or sink overflow can lead to water penetration to countertop wood, the cabinet interior and areas behind cabinets. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth.

A number of aquariums and terrariums were located in classrooms. Aquariums should be properly maintained to prevent microbial/algae growth, which can emit unpleasant odors. Similarly, terrariums should be properly maintained to ensure soil does not become a source for mold growth.

Other Concerns

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. On the day of assessment, outdoor carbon monoxide concentrations were non-detect (ND). Carbon monoxide levels measured in the school were also ND (Table 1).

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a).

Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. Outdoor PM2.5 concentrations were measured at 4 $\mu g/m^3$ (Table 1). PM2.5 levels measured in the school were between 1 to 13 $\mu g/m^3$, which were below the NAAQS of 65 $\mu g/m^3$ (Table 1). Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices, operating an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. In an effort to identify materials that can potentially increase indoor TVOC concentrations, MDPH staff examined classrooms for products containing these respiratory irritants. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Spray cleaning products and unlabelled spray bottles were observed on countertops in a number of classrooms. Cleaning products contain VOCs and other chemicals, which can be irritating to the eyes, nose and throat and should be stored properly and kept out of reach of students. Many of these products appeared to have been brought from individual's homes, without the knowledge of school personnel who maintain material data safety sheets (MSDS) for chemicals used in the school. Therefore it is unlikely that MSDS' for these materials are available on site.

In addition, surface cleaning/disinfectant wipes are used extensively throughout the school. These wipes are saturated with low dose cleaning/disinfectant agents. Care should be taken when using them to ensure that agents contained in wipes are compatible with agents used for cleaning classrooms. These wipes should also be clearly labeled and placed in a location away from hand wipes.

Several other conditions that can affect indoor air quality were noted during the assessment. In some classrooms, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. A number of exhaust/return vents and personal/ceiling fan blades had accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles. Accumulated dust can also be re-aerosolized when fans are activated. Dust can be irritating to eyes, nose and respiratory tract.

Univents are normally equipped with filters that strain particulates from airflow. Filters used in univents at the HEES provide minimal filtration (Picture 10). In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent (Minimum Efficiency Reporting Value equal to 9) would be sufficient to reduce many airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by increased resistance, a condition known as pressure drop. Prior to any increase of filtration, each univent should be evaluated by a ventilation engineer to ascertain whether they can maintain function with more efficient filters.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs. Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Lastly, food and re-use of food containers was observed in a number of areas. Food is an attractant to pests and rodents. Proper food storage is an integral component in preventing pest infestation. Food should be properly stored and clearly labeled. Reuse of food containers is not recommended since food residue adhering to the surface may serve to attract pests.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made:

1. Operate all ventilation systems throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange. To increase airflow in classrooms, set univent controls to "high".
2. Inspect exhaust motors and belts for proper function. Repair and replace as necessary.
3. Work with town/school officials to develop a preventative maintenance program for all HVAC equipment system-wide.

4. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
5. Consider adopting a balancing schedule of every 5 years for mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
6. Change filters for air-handling equipment as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.
7. Consider contacting an HVAC engineering firm to have ventilation equipment in the gymnasium balanced and carbon dioxide monitors recalibrated.
8. Use openable windows in conjunction with classroom univents and exhaust vents to increase air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).
10. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard.

11. Replace water-damaged ceiling tiles once repairs are made. Examine the area above and around water-damaged areas for mold growth. Disinfect areas with an appropriate antimicrobial as needed.
12. Consider discontinuing the use of mulch in close proximity to the building to prevent the entrainment of musty odors.
13. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
14. Store cleaning products properly and out of reach of students. Ensure spray bottles are properly labeled in the event of an emergency. Maintain MSDS for all cleaning products in a central location.
15. Clean fans/blades, exhaust and supply vents periodically to prevent excessive dust build-up.
16. Consider replacing tennis balls with alternative glides.
17. Consider adopting the US EPA document, "Tools for Schools", to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.
18. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://mass.gov/dph/indoor_air

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Picture 1

Classroom univent, note materials placed above and in front

Picture 2

Ceiling-mounted univent

Picture 3

Ceiling-mounted exhaust vent, note proximity to door

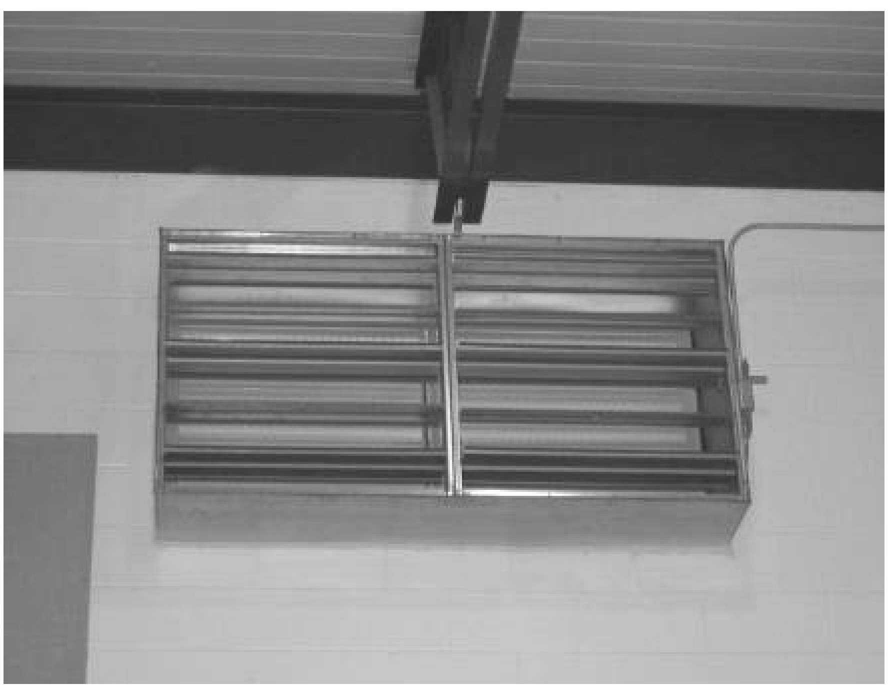
Picture 4

Wall-mounted exhaust vent

Picture 5

Unit exhaust, note desk placed in front, limiting airflow

Picture 6



Auxiliary fresh air vent in gymnaisum

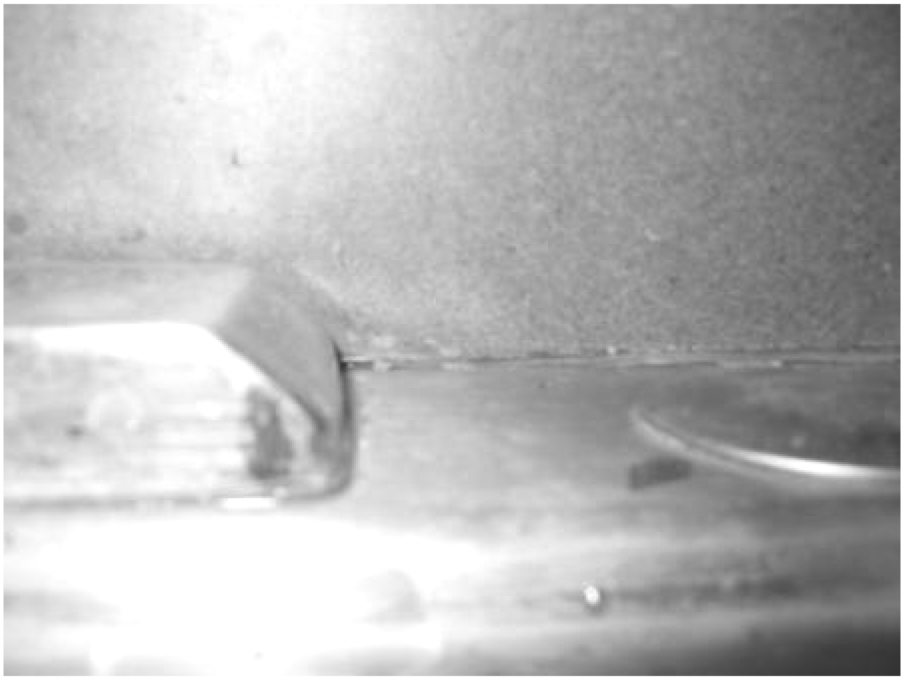
Picture 7

Water-damaged ceiling tiles

Picture 8

Plants on top of univent

Picture 9



Breach between sink counter and backsplash

Picture 10

Univent filter

Huckleberry Hill Elementary School | **Indoor Air Results**

5 Knoll Road, Lynnfield, MA 01940 | **Date: 05/10/2006**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Background		49	72	395	ND	ND	4				Heavy rain
cafe	2	71	45	853	ND	ND	13	N	Y ceiling (weak)	Y wall (weak)	Hallway DO,
conference	0	70	44	780	ND	ND	1	Y # open: 0 # total: 3	Y ceiling	Y ceiling	Hallway DO,
exam	2	69	51	942	ND	ND	1	N	Y ceiling	Y ceiling location	Inter-room DO,
guidance	0	70	43	1301	ND	ND	6	N	Y ceiling	Y ceiling	breach sink/counter, CD.
gym	0	70	46	680	ND	ND	11	N	Y ceiling	Y wall	DEM.
library conf	7	71	44	1027	ND	ND	5	Y # open: 0 # total: 2	Y ceiling	N	

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

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library office	0	71	43	1043	ND	ND	7	N	Y ceiling	Y ceiling	cleaners, plants.
main office	4	70	43	805	ND	ND	1	Y # open: 0 # total: 1	Y ceiling	Y ceiling	Hallway DO,
media library	40	71	44	948	ND	ND	6	Y # open: 0 # total: 18	Y ceiling	Y wall	DEM.
nurse waiting area	0	68	47	936	ND	ND	1	N	Y ceiling	Y ceiling	Hallway DO, Inter-room DO,
nurse's office	2	69	49	905	ND	ND	1	Y # open: 0 # total: 3	Y ceiling	Y ceiling	Hallway DO, Inter-room DO, plants.
ot/pt	0	71	35	886	ND	ND	1	Y # open: 0 # total: 2	Y univent furniture	Y ceiling location	cleaners.
principal office	0	70	44	908	ND	ND	2	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO, plants.

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Huckleberry Hill Elementary School **Indoor Air Results**

5 Knoll Road, Lynnfield, MA 01940 **Date: 05/10/2006**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (μg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
resting	0	69	48	1025	ND	ND	1	Y # open: 0 # total: 3	Y ceiling	Y ceiling	Inter-room DO,
speech and language	0	71	43	1368	ND	ND	7	Y # open: 0 # total: 2	Y univent (off)	Y ceiling	Hallway DO, DEM, univent off-noise.
101	0	71	45	932	ND	ND	7	Y # open: 0 # total: 9	Y univent furniture	Y wall furniture	Hallway DO, TB, cleaners.
102	3	72	44	922	ND	ND	5	Y # open: 0 # total: 9	Y univent	Y wall	Hallway DO, DEM, cleaners, wood shop odors.
103	23	75	47	1072	ND	ND	10	Y # open: 0 # total: 9	Y univent (off)	Y wall	DEM, TB, plants.
104	22	71	47	1207	ND	ND	7	Y # open: 0 # total: 9	Y univent	Y wall furniture	Hallway DO, TB.
105	0	71	41	682	ND	ND	ND	Y # open: 0 # total: 9	Y univent	Y wall	DEM, cleaners, plants.

ppm = parts per million
μg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
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UF = upholstered furniture
VL = vent location
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Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
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106	17	72	46	1396	ND	ND	10	Y # open: 0 # total: 9	Y univent	Y wall	breach sink/counter, DEM, TB, cleaners, wood chip odor.
201	1	70	42	1737	ND	ND	6	Y # open: 0 # total: 3	Y univent boxes items furniture plant(s)	Y ceiling location	Hallway DO, breach sink/counter, cleaners.
202	2	70	43	1506	ND	ND	6	N	Y univent plant(s)	Y ceiling location	breach sink/counter, DEM, cleaners, plants.
204	15	70	44	1823	ND	ND	10	Y # open: 0 # total: 6			DEM, FC re-use, food use/storage, plants.
205	0	69	42	1456	ND	ND	11	Y # open: 0 # total: 6	Y univent (off)	N	Hallway DO, #WD-CT: 6, DEM, cleaners, plants.

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									Supply	Exhaust	
206	21	70	44	1254	ND	ND	9	Y # open: 0 # total: 3	Y univent boxes items furniture	Y unit exhaust furniture	Hallway DO, breach sink/counter, DEM, TB, plants.
207	14	71	44	1303	ND	ND	8	Y # open: 0 # total: 3	Y univent boxes items furniture	Y unit exhaust boxes furniture	DEM, cleaners, items.
208	21	71	45	1480	ND	ND	9	Y # open: 0 # total: 3	Y univent furniture	Y unit exhaust furniture	Hallway DO, DEM, cleaners.
209	18	71	44	1539	ND	ND	12	Y # open: 0 # total: 3	Y univent boxes items furniture	Y unit exhaust	Hallway DO, breach sink/counter, DEM, aqua/terra, cleaners, FC re-use.

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210 A Reading	3	72	41	1213	ND	ND	4	Y # open: 0 # total: 1	Y univent	Y ceiling	AP, DEM.
301	20	71	43	959	ND	ND	5	Y # open: 0 # total: 9	Y univent	Y wall boxes items	Hallway DO, DEM, TB, cleaners, plants, bleach.
302	20	73	44	1587	ND	ND	8	Y # open: 0 # total: 9	Y univent (off) boxes furniture	Y wall (off) dust/debris	Hallway DO, DEM, cleaners.
304	20	71	44	1103	ND	ND	6	Y # open: 0 # total: 9	Y univent	Y wall	Hallway DO, DEM, cleaners, plants.
305	19	71	44	1869	ND	ND	12	Y # open: 0 # total: 9	Y univent boxes items plant(s)	Y wall	Hallway DO, DEM, cleaners.

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306	0	72	43	959	ND	ND	8	Y # open: 0 # total: 9	Y univent	Y wall	Hallway DO, DEM, plants, bleach.
307A	3	69	47	976	ND	ND	8	Y # open: 0 # total: 3	Y univent	N	Hallway DO,
307B	4	69	46	1099	ND	ND	7	Y # open: 0 # total: 2	Y univent	N	Hallway DO, #WD-CT: 4, DEM, wet toner copier/Risograph.
308	19	72	47	1712	ND	ND	12	Y # open: 0 # total: 5	Y univent	N	
309	21	70	47	1260	ND	ND	13	Y # open: 0 # total: 5	Y univent	Y furniture	Hallway DO, DEM, TB, cleaners.
310	0	72	41	914	ND	ND	4	Y # open: 0 # total: 6	Y univent	N	CD, DEM.
311	22	71	47	1246	ND	ND	8	Y # open: 0 # total: 5	Y univent boxes	Y furniture	Hallway DO, CD, DEM, items.

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